AIRSAR Integrated Processor Documentation

DATA FORMATS

Version 0.01
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1.0 Data Formats

The Integrated AIRSAR processor produces two data products; the standard AIRSAR products in frame and synoptic format, and the integrated TOPSAR product. These products will be described separately below. We first describe the general file structure, and then the different data types for the different products.

1.1 General File Structure

Figure 1.1 shows the general data file structure. The data are preceeded by a number of header records. Note that the length of a record is variable from data set to data set, but is constant in a data file. This value is supplied in the first header record (See discussion below). When processing data, a constant number of raw data lines are processed. However, the processed image size depends on the aircraft motion during the scene, which causes different data sets to have slightly different file sizes. Also note that not all header records indicated in Figure 1.1 are present in all files. Only those files containing actual radar cross-section data will have the calibration header with its associated radiometric correction vector(s) present.

1.2 Header Definitions

In this section we provide the description of all the headers. All headers, including the radiometric correction vectors, are written in ASCII. Except for the radiometric correction vectors, each header consists of a number of different fields, and each field is 50 characters long. The field descriptor is left justified in the 50 character string, followed by the value for that descriptor right justified in the same 50 character string. We shall now describe each header in detail.

1.2.1 First Header

The first record of the file (see Figure 1.1) is a header record describing the general characteristics of the file.   This record is described below and is referred to as the *new header.*   Note that one of the parameters in the new header (parameter number 13) indicates the location of the first image line. This allows one to add any number of additional headers, as long as this parameter is updated. *Users writing software to analyze AIRSAR data should use the information in the new header when reading data or header information.*

The first header contains general information about the file. The following are a table and definitions of the parameter header fileds. To make the header easier to read, we added the number of the fileds on the left and a ruler at the top.

```
                 0         1         2         3         4
          12345678901234567890123456789012345678901234567890
      1   RECORD LENGTH IN BYTES =                  IIIIIIII
      2   NUMBER OF HEADER RECORDS =                IIIIIIII
      3   NUMBER OF SAMPLES PER RECORD =            IIIIIIII
      4   NUMBER OF LINES IN IMAGE =                IIIIIIII
      5   NUMBER OF BYTES PER SAMPLE =              IIIIIIII
      6   JPL AIRCRAFT SAR PROCESSOR VERSION           RR.RR
      7   DATA TYPE =                              CCCCCCCCC
      8   RANGE PROJECTION =                          CCCCCC
      9   RANGE PIXEL SPACING (METERS) =           RRRR.RRRR
     10   AZIMUTH PIXEL SPACING (METERS) =         RRRR.RRRR
     11   BYTE OFFSET OF OLD HEADER =               IIIIIIII
     12   BYTE OFFSET OF USER HEADER =              IIIIIIII
     13   BYTE OFFSET OF FIRST DATA RECORD =        IIIIIIII
     14   BYTE OFFSET OF PARAMETER HEADER =         IIIIIIII
     15   LINE FORMAT OF DATA =                      CCCCCCC
     16   BYTE OFFSET OF CALIBRATION HEADER =       IIIIIIII
     17   BYTE OFFSET OF DEM HEADER =               IIIIIIII
     18-20    RESERVED FOR LATER USE
```

The First Header contains 20 fields, 17 of which are currently defined. Each field is 50 bytes in length and contains only ASCII characters. The first part of each field is a description of the field, with the actual value of the field being right justified in the format shown in the table. ("I" corresponds to integer ASCII values, "R" to real ASCII values and "C" to character values.) Fields which are not determined will remain blank. Following is a description of the defined fields:

Field 1   **RECORD LENGTH IN BYTES:** This entry indicates how many bytes per record are found in the file. This number varies from file to file and is a function of the data type and the number of pixels in range.

Field 2   **NUMBER OF HEADER RECORDS:** This entry has a minimum value of 2 for data directly out of the intgrated processor and includes the New Header, the Parameter Header and possibly the Calibration Header. *Users adding additional headers should update this entry.*

Field 3   **NUMBER OF SAMPLES PER RECORD:** This indicates how many samples of data are in each image record. This number is equal to the record length divided by the number of bytes per sample. This number may vary from scene to scene and is a function of the topography of the scene.

Field 4   **NUMBER OF LINES IN IMAGE:** A line is equivalent to a record, and this value indicates the number of records corresponding to image data (not counting the headers). This number varies from scene to scene and is a function of the topography of the scene, as well as the aircraft attitude during data acquisition.
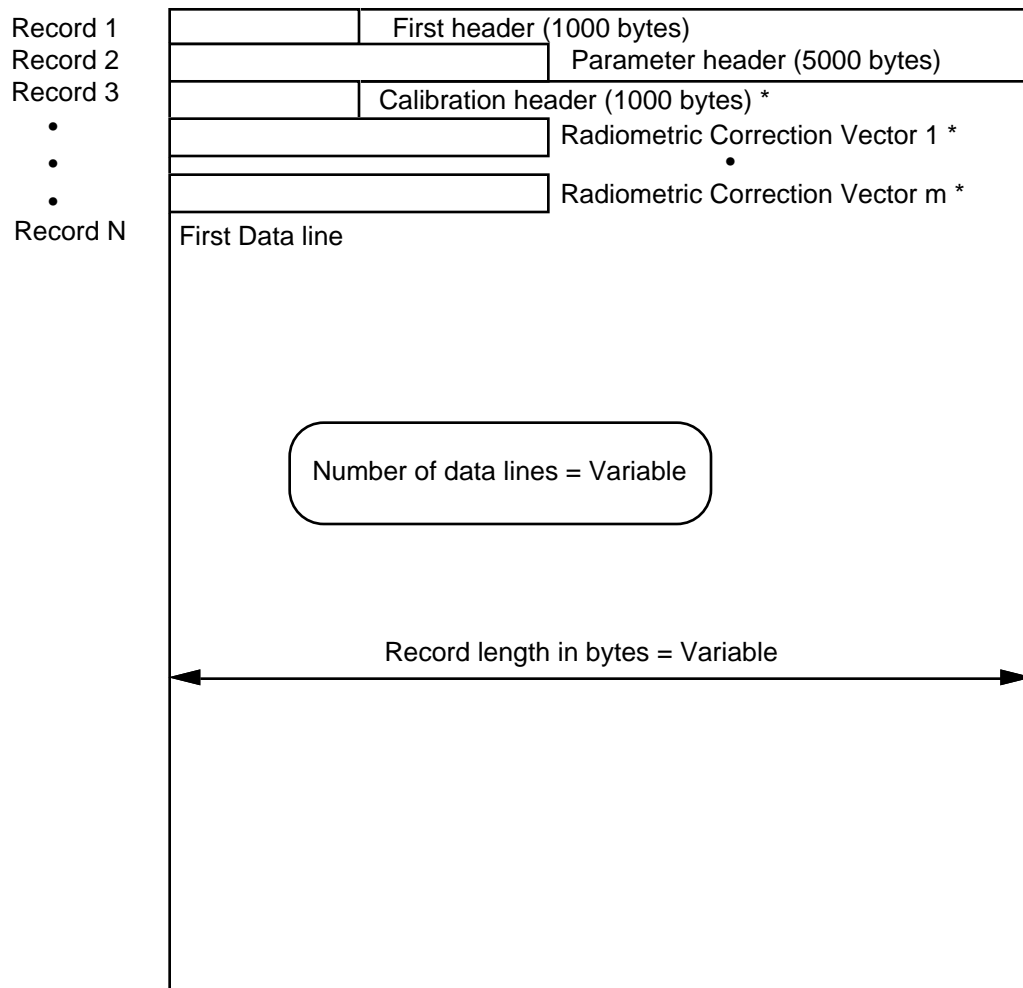
Figure 1.1 *General data file structure for the Intgerated AIRSAR processor. The headers denoted by * may not be present in all data files.*

Field 5   **NUMBER OF BYTES PER SAMPLE:** For compressed data, (both CM and compressed scattering matrix data) it takes 10 bytes to represent one sample, for floating point data it takes 4 bytes, integer data (such as the DEM) requires 2 bytes, and byte data (such as the correlation coefficient image) requires a single byte per sample.

Field 6   **JPL AIRCRAFT SAR PROCESSOR VERSION:** This number determines the processor version used to produce the data. The integrated processor has version numbers larger than 5.

Field 7   **DATA TYPE:** Describes the type of data in the file. The following are possible data types:
- COMPRESSED = standard compressed Stokes matrix data
- SCATTERING MATRIX COMPRESSED = compressed single look polarimetric data
- INTEGER*2 = 16 bit data (including sign)
- BYTE = 8 bit data

Field 8   **RANGE PROJECTION:** Documents the type of range samples found in the file: either slant range or ground range. Standard format is "SLANT" range for all AIRSAR data types, and "GROUND" for all TOPSAR data.

Field 9   **RANGE PIXEL SPACING (METERS):** Size of the range pixel in the specified projection. This means if the projection is slant range, the pixel size in this field is in slant range, while if the projection is ground range the pixel size is in ground range.

Field 10   **AZIMUTH PIXEL SPACING (METERS):** Distance between azimuth pixels.

Field 11   **BYTE OFFSET OF OLD HEADER:** Determines the location of the old header within this file.   This value is always zero, since the old header is no longer supplied with the data.

Field 12   **BYTE OFFSET OF USER HEADER:** If users wish to add their own header, this field will indicate its location. The absence of user header is indicated by a byte offset of 0. *Users adding additional headers should update this field.* This offset is from the start of the file.

Field 13   **BYTE OFFSET OF FIRST DATA RECORD:** This value determines the location of the start of the image data. *Users adding additional headers should update this field.* This offset is from the start of the file.

Field 14   **BYTE OFFSET OF PARAMETER HEADER:** This value determines the location of the Parameter Header. This offset is from the start of the file.

Field 15   **LINE FORMAT OF DATA:** Describes the orientation of the data. May be "AZIMUTH" or "RANGE". The format used for all date produced with the integrated processor is "RANGE".   This field indicates the changing dimension in the image for each record. For example, data in "RANGE" line format means that each line contains data at a constant along-track position, and that each pixel in the line represents a different cross-track (or range) position in the line.

Field 16   **BYTE OFFSET TO CALIBRATION HEADER:** This value determines the location of the Calibration Header. This offset is from the start of the file. Note that the calibration header is not present in all files. If no calibration header is present, this value will be 0.

Field 17 **BYTE OFFSET TO DEM HEADER:** This value determines the location of the DEM Header. This offset is from the start of the file. Note that the DEM header is only present in DEM files. If no DEM header is present, this value will be 0.

Note that the first header contains a special field (field 12) which is a byte offset to a user header. This field allows users to add their own headers to AIRSAR data. If this is done, both fields 12 and 13 of the new header should be updated to have the correct offsets. *Users should not use the standard AIRSAR headers to store information.* Some of the fields currently not defined are to be used in the future, and some data or information may be lost if user software writes over these fields.

1.2.2 Parameter Header

The second header record is the *parameter header.* This header record was introduced in 1991 (processor version 3.50 and greater) and updated with the integrated processor. The parameter header is present with all data currently processed with the integrated processor. The parameter header contains information specific to the scene and the fields are defined below.

The following are a table and definitions of the parameter header fileds. To make the header easier to read, we added the number of the fileds on the left and a ruler at the top.

```
                        1         2         3         4         5
                12345678901234567890123456789012345678901234567890

    1       NAME OF HEADER                             PARAMETER
    2       SITE NAME           CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
    3       LATITUDE OF SITE (DEGREES)                   ±RR.RRRR
    4       LONGITUDE OF SITE (DEGREES)                 ±RRR.RRRR
    5       IMAGE TITLE         CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
    6       HDDT ID                                         IIIII
    7       FREQUENCY                                           C
    8       POLARIZATION                                       CC
    9       CCT TYPE                                           CC
    10      CCT ID                                           IIII
    11      ARCHIVAL FLAG                                        I
    12      TRANSFER START FRAMECOUNT              IIIIIIIIII
    13      PROCESSOR START FRAMECOUNT             IIIIIIIIII
    14      LATITUDE AT START OF SCENE (DEGREES)     ±RR.RRRR
    15      LONGITUDE AT START OF SCENE (DEGREES)   ±RRR.RRRR
    16      LATITUDE AT END OF SCENE (DEGREES)       ±RR.RRRR
    17      LONGITUDE AT END OF SCENE (DEGREES)     ±RRR.RRRR
    18      APPROXIMATE STARTING HDDT FOOTAGE           IIII
    19      DATE OF ACQUISITION (GMT)               II-CCC-II
    20      TIME OF ACQUISITION: GMT DAY                  III
```

```
21   TIME OF ACQUISITION: SECONDS IN DAY        RRRRR.R
22   RECORD WINDOW DURATION (MICROSECONDS)         III
23   FREQUENCIES COLLECTED                          CCC
24   DIGITAL DELAY (MICROSECONDS)                 RRR.R
25   CHIRP DELAY (MICROSECONDS)                   RRR.R
26   PROCESSOR DELAY (RAW SAMPLES)                 IIII
27   PRF AT START OF TRANSFER (HZ)               RRRR.R
28   SAMPLING RATE (MHZ)                         RRR.RR
29   CENTER FREQUENCY AT VIDEO (MHZ)             RRR.RR
30   CHIRP BANDWIDTH (MHZ)                       RRR.RR
31   TYPE OF CHIRP USED (ANALOG OR DIGITAL)     CCCCCCC
32   PULSE LENGTH (MICROSECONDS)                 RRR.RR
33   PROCESSOR WAVELENGTH (METERS)                .RRRRR
34   BAROMETRIC ALTITUDE (METERS)                RRRRR.R
35   RADAR ALTIMETER ALTITUDE (METERS)           RRRRR.R
36   ALTITUDE USED IN PROCESSOR (METERS)         RRRRR.R
37   ELEVATION OF INVESTIGATOR SITE (METERS)       RRRRR
38   AIRCRAFT TRACK ANGLE (DEGREES)               RRR.R
39   AIRCRAFT YAW ANGLE (DEGREES)                ±RR.R
40   AIRCRAFT PITCH ANGLE (DEGREES)              ±RR.R
41   AIRCRAFT ROLL ANGLE (DEGREES)               ±RR.R
42   PROCESSOR YAW ANGLE USED (DEGREES)          ±RR.R
43   PROCESSOR PITCH ANGLE USED (DEGREES)        ±RR.R
44   PROCESSOR ROLL ANGLE USED (DEGREES)         ±RR.R
45   NOMINAL PRF RATIO (HZ/KNOT)                  R.RRR
46   NOMINAL PRF RATIO (1/METERS)                 R.RRR
47   PRF RATIO CORRECTION FACTOR USED            R.RRRR
48   RANGE FFT SIZE                                IIII
49   AZIMUTH FFT SIZE                             IIII
50   FRAME SIZE (RANGE LINES)                      IIII
51   NUMBER OF FRAMES PROCESSED                     III
52   RANGE ALIGNMENT DELAY USED, HH (MICROSEC)  ±R.RRRR
53   RANGE ALIGNMENT DELAY USED, HV (MICROSEC)  ±R.RRRR
54   RANGE ALIGNMENT DELAY USED, VH (MICROSEC)  ±R.RRRR
55   RANGE ALIGNMENT DELAY USED, VV (MICROSEC)  ±R.RRRR
56   NEAR SLANT RANGE (METERS)                  RRRRR.RR
57   FAR SLANT RANGE (METERS)                   RRRRR.RR
58   NEAR LOOK ANGLE (DEGREES)                     RR.R
59   FAR LOOK ANGLE (DEGREES)                      RR.R
60   NUMBER OF LOOKS PROCESSED IN AZIMUTH            II
61   NUMBER OF LOOKS PROCESSING IN RANGE            II
62   RANGE WEIGHTING USED                          CCCC
63   RANGE WEIGHTING COEFFICIENT                  R.RRR
64   AZIMUTH WEIGHTING USED                        CCCC
65   AZIMUTH WEIGHTING COEFFICIENT               R.RRR
66   PERCENT OF PRF BANDWIDTH PROCESSED            RR.R
67   DESKEW FLAG (1=DESKEWED, 2=NOT DESKEWED)        I
68   SLANT RANGE SAMPLE SPACING (METERS)          RR.RR
69   NOMINAL SLANT RANGE RESOLUTION (METERS)       RR.R
```

```
70      AZIMUTH SAMPLE SPACING (METERS)              RR.RR
71      NOMINAL AZIMUTH RESOLUTION (METERS)           RR.R
72      NUMBER OF INTERPOLATION POINTS USED IN RMC      II
73      AZIMUTH REFERENCE SIZE/LOOK, NEAR RANGE       IIII
74      AZIMUTH REFERENCE SIZE/LOOK, FAR RANGE        IIII
75      IMAGE CENTER LATITUDE (DEGREES)           ±RR.RRRR
76      IMAGE CENTER LONGITUDE (DEGREES)         ±RRR.RRRR
77      CALTONE VIDEO FREQUENCY (MHZ)             RRR.RRRR
78      CALTONE POWER MEASURED, DB, HH              RRR.R
79      CALTONE POWER MEASURED, DB, HV              RRR.R
80      CALTONE POWER MEASURED, DB, VH              RRR.R
81      CALTONE POWER MEASURED, DB, VV              RRR.R
82      CALIBRATION FACTOR APPLIED, DB, HH          RRRRR
83      CALIBRATION FACTOR APPLIED, DB, HV          RRRRR
84      CALIBRATION FACTOR APPLIED, DB, VH          RRRRR
85      CALIBRATION FACTOR APPLIED, DB, VV          RRRRR
86      MEASURED AND CORRECTED HV/VH POWER RATIO    R.RRR
87      MEASURED AND CORRECTED HV/VH PHASE (DEG)    RRR.R
88      CALTONE PHASE MEASURED, DEG, HH             RRR.R
89      CALTONE PHASE MEASURED, DEG, HV             RRR.R
90      CALTONE PHASE MEASURED, DEG, VH             RRR.R
91      CALTONE PHASE MEASURED, DEG, VV             RRR.R
92      GENERAL SCALE FACTOR                        RRR.R
93      GPS ALTITUDE, M                           RRRRR.R
94-100  TBD
```

The Parameter Header contains 100 fields, 87 of which are currently defined. Each field is 50 bytes in length and contains only ASCII characters. The first part of each field is a description of the field, with the actual value of the field being right justified in the format shown in the table. ("I" corresponds to integer ASCII values, "R" to real ASCII values and "C" to character values.) Fields which are not determined will remain blank, e.g. if no HH data are represented in the image, field 78 (the caltone power measured for HH) will have no value written in it. Following is a description of the defined fields:

Field 1   **NAME OF HEADER:** This field defines the header record. For the Parameter Header, this field is always "PARAMETER"

Field 2   **SITE NAME:** Name of experimental site. Most likely assigned by Principal Investigator of the prime target of the data pass. This target may not be in this image.

Field 3   **LATITUDE OF SITE (DEGREES,MINUTES):** The latitude of the prime target of the data pass. Assigned prior to data acquisition.

Field 4   **LONGITUDE OF SITE (DEGREES,MINUTES):**   The longitude of the prime target of the data pass. Assigned prior to data acquisition.

Field 5   **IMAGE TITLE:**   Name of this particular image processed from the data pass. Name is assigned by processor operator.

Field 6   **HDDT ID:** Identification of the High Density Digital tape on which the raw data were recorded. ID format is YYNNN where YY indicates the year of acquisition, and NNN is an incremental tape number for the year.

Field 7   **FREQUENCY:**   The frequency band of the data.   Current AIRSAR possibilities are C, L and P.

Field 8   **POLARIZATION:**   Transmit and receive polarization of data, either HH, HV, VH, VV or AL for Stokes or Compressed Scattering Matrix data.

Field 9   **CCT TYPE:** Indicates the product that is represented by the imagery. 2 letter codes currently supported:
    CM = Compressed Stokes Matrix
    CS = Compressed Scattering Matrix
    SY = Synoptic data (VAX floating point format)
    TS = TOPSAR Data

Field 10   **CCT ID:** This is a code that uniquely identifies this data product.

Field 11   **ARCHIVAL FLAG:** = "1" if data is archived and available through requests to the JPL radar data center, = "0" if not archived or available.

Field 12   **TRANSFER START FRAMECOUNT:** The frame count corresponding to the first line of data transferred from HDDT for processing this scene.

Field 13   **PROCESSOR START FRAMECOUNT:** The frame count corresponding to the first line input to the processor for this image. This is greater than or equal to the start framecount in the previous field.

Field 14   **LATITUDE AT START OF SCENE (DEGREES):** The latitude of the near range pixel at the start of the scene.

Field 15   **LONGITUDE AT START OF SCENE (DEGREES):** The longitude of the near range pixel at the start of the scene.

Field 16   **LATITUDE AT END OF SCENE (DEGREES):** The latitude of the near range pixel at the end of the scene.

Field 17   **LONGITUDE AT END OF SCENE (DEGREES):** The longitude of the near range pixel at the end of the scene.

Field 18   **APPROXIMATE STARTING HDDT FOOTAGE:**   The approximate footage of the HDDT at the start of the transfer.   One HDDT is about 9,000

feet in length, and contains 15 minutes of recorded data. Used primarily with HDDTs recorded with the Fairchild M85 recorders. In the case of the digital cassettes recorded with the Sony recorders, this value is the IDR count for the start of the transfer.

Field 19 **DATE OF ACQUISITION (GMT):** The GMT date of acquisition at the start of this image, *i.e.* at the time of the processor start framecount.

Field 20 **TIME OF ACQUISITION: GMT DAY:** The GMT day of the year corresponding to the time at the start of this image *i.e.* at the time of the processor start framecount.

Field 21 **TIME OF ACQUISITION: SECONDS IN DAY:** The number of seconds past GMT midnight corresponding to the time at the start of this image, *i.e.* at the time of the processor start framecount.

Field 22 **RECORD WINDOW DURATION: (MICROSECONDS):** The total time the radar is digitizing radar echoes from a given transmitted pulse. This value is a nominal value, as the exact window duration is determined by the aircraft velocity and therefore may vary about this value.

Field 23 **FREQUENCIES COLLECTED:** Indicates which radars where operating during acquisition. Value is a concatenation of P,L and C letters.

Field 24 **DIGITAL DELAY (MICROSECONDS):**   This value together with the chirp delay determines the near slant range.

Field 25 **CHIRP DELAY (MICROSECONDS):**   The time between the "PRF EVENT" and the transmission of the actual radar pulses from the transmitters.

Field 26 **PROCESSOR DELAY (RAW SAMPLES):** The number of raw range samples skipped by while transfering data into the ground processor.

Field 27 **PRF AT START OF TRANSFER (HZ):** The pulse repetition frequency per channel of the radar at the start of the data transfer. Since the PRF is determined by the aircraft velocity (see PRF RATIO), this value may change throughout the image.

Field 28 **SAMPLING RATE (MHZ):** Sampling rate of the analog to digital converters used to digitize the video signal.

Field 29 **CENTER FREQUENCY AT VIDEO (MHZ):**   The frequency corresponding to the center of the range bandwidth at video.

Field 30 **CHIRP BANDWIDTH (MHZ):** The bandwidth of the transmitted chirp. Currently 20 and 40 MHz are supported.

Field 31   **TYPE OF CHIRP USED (ANALOG OR DIGITAL):** Pre-1989 data used an analog (surface acoustic wave device) chirp generator. In 1989 and later years, a digitally generated chirp became the standard pulse form.

Field 32   **PULSE LENGTH (MICROSECONDS):** The time extent of the transmitted pulse (chirp). 5 or 10 microseconds are supported.

Field 33   **PROCESSOR WAVELENGTH (METERS):** The wavelength used in the processor as the radar wavelength. NOTE: This value is calculated from the RF center frequency of the radars, and hence becomes a function of the chirp bandwidth used-see Table 3.2.   This is especially significant at P-Band.

Field 34   **BAROMETRIC ALTITUDE (METERS):** The altitude as determined by the DC-8 barometric system. The aircraft uses this number to determine its altitude, however, it may be in error up to ±1000 feet due to varying local weather conditions.

Field 35   **RADAR ALTIMETER ALTITUDE (METERS):** This is the altitude of the DC-8 as determined by its radar altimeter. This value gives the distance between the aircraft and the ground "more or less" directly beneath it. It may not apply to the altitude above the imaged site (which is to the left of the aircraft).

Field 36   **ALTITUDE USED IN PROCESSOR (METERS):** The processor requires an altitude to calculate the antenna gain pattern corrections to apply to the data. This is the value that was used during the processing.

Field 37 **ELEVATION OF INVESTIGATORS SITE (METERS):**   Each investigator (or their representative) provides the altitude (above sea level) of the site. It typically applies to the location given in field #2, "SITE NAME".

Field 38   **AIRCRAFT TRACK ANGLE (DEGREES):** This is the direction (with respect to true north) the aircraft was flying at the start of the data transfer.

Field 39   **AIRCRAFT YAW ANGLE (DEGREES):** Aircraft yaw at the beginning of the image as provided by radar inertial navigation system. Positive yaw rotates the aircraft clockwise when viewed from above. NOTE: yaw angle = - drift angle.

Field 40   **AIRCRAFT PITCH ANGLE (DEGREES):** Aircraft pitch at the beginning of the image as provided by radar inertial navigation system. Positive pitch raises the aircraft nose.

Field 41   **AIRCRAFT ROLL ANGLE (DEGREES):** Aircraft roll at the beginning of the image as provided by radar inertial navigation system. Positive roll lifts the left wing.

Field 42   **PROCESSOR YAW ANGLE USED (DEGREES):** Yaw angle used by the processor. The integrated processor updates this parameter for every patch processed to ensure the best quality image.

Field 43   **PROCESSOR PITCH ANGLE USED (DEGREES):** Pitch angle used by the processor. The integrated processor updates this parameter for every patch processed to ensure the best quality image.

Field 44   **PROCESSOR ROLL ANGLE USED (DEGREES):** Roll angle used by the processor. The integrated processor updates this parameter for every patch processed to ensure the best quality image.

Field 45   **NOMINAL PRF RATIO (HZ/KNOTS):** The PRF RATIO is the ratio between the radar prf per channel, and the speed of the aircraft in knots. Until the end of 1992, this value was typically 0.68, but since 1993, this value is 1.0. The PRF tracks the velocity in order to maintain a constant spacing between radar measurements on the ground. Changes in velocity of 1/8 knot will cause a change in the PRF.

Field 46   **NOMINAL PRF RATIO (1/METERS):** The same as the previous value, but converted in units to 1/meters. The inverse of this value gives the distance the aircraft travels between two successive pulses of the same polarization. This distance is FIXED by this ratio. If the aircraft changes speed, the PRF tracks accordingly to maintain the fixed spacing.

Field 47   **PRF RATIO CORRECTION FACTOR USED:** A factor that is multiplied by the nominal PRF ratio. This will compensate for any determined bias in the aircraft velocity during the data acquisition. Note the pixel spacing in azimuth is also adjusted by this factor.

Field 48   **RANGE FFT SIZE:** Number of complex points used in range FFT for range processing. (2k complex point FFT requires 4k input real raw data samples)

Field 49   **AZIMUTH FFT SIZE:** Number of complex points used in the azimuth forward FFT. Inverse azimuth FFT length is 1/(number of looks) times this value.

Field 50   **FRAME SIZE (RANGE LINES):** Number of range lines in a frame. Typically this value is half the azimuth FFT size.

Field 51   **NUMBER OF FRAMES PROCESSED:** The number of frames used to produce this image.

Field 52   **RANGE ALIGNMENT DELAY USED, HH (MICROSEC):** The delay used in the range processor to shift the HH channel. Required to align all channels across frequencies and polarizations.

Field 53 **RANGE ALIGNMENT DELAY USED, HV (MICROSEC):** The delay used in the range processor to shift the HV channel. Required to align all channels across frequencies and polarizations.

Field 54 **RANGE ALIGNMENT DELAY USED, VH (MICROSEC):** The delay used in the range processor to shift the VH channel. Required to align all channels across frequencies and polarizations.

Field 55 **RANGE ALIGNMENT DELAY USED, VV (MICROSEC):** The delay used in the range processor to shift the VV channel. Required to align all channels across frequencies and polarizations.

Field 56 **NEAR SLANT RANGE (METERS):** The slant range to the first range pixel in the image. This value is the range of closest approach, i.e. at zero Doppler.

Field 57 **FAR SLANT RANGE (METERS):** The slant range to the last range pixel in the image. This value is the range of closest approach, i.e. at zero Doppler.

Field 58 **NEAR LOOK ANGLE (DEGREES):** The angle between vertical (down from the aircraft) and the near range vector calculated using the near range parameter and the altitude used by the processor.

Field 59 **FAR LOOK ANGLE (DEGREES):** The angle between vertical (down from the aircraft) and the far range vector calculated using the far range parameter and the altitude used by the processor.

Field 60 **NUMBER OF LOOKS PROCESSED IN AZIMUTH:** The number of single-look pixels added to form the multi-look image.

Field 61 **NUMBER OF LOOKS PROCESSED IN RANGE:** The number of looks the processor produces and averages by dividing up the range bandwidth.

Field 62 **RANGE WEIGHTING USED:** Type of frequency domain weighting applied in range. Possible types are COS2, COS1, NONE.

Field 63 **RANGE WEIGHTING COEFFICIENT:** The coefficient used by the weighting function.

Field 64 **AZIMUTH WEIGHTING USED:** Type of azimuth weighting used.

Field 65 **AZIMUTH WEIGHTING COEFFICIENT:** The coefficient used by the weighting function.

Field 66 **PERCENT OF PRF BANDWIDTH PROCESSED:** The 3dB power points of the Doppler bandwidth are contained within the PRF bandwidth. This indicates the percentage of the PRF bandwidth used during processing. Typically, the 3dB Doppler bandwidth is contained within about 80% of the PRF bandwidth.

Field 67 **DESKEW FLAG (1=DESKEWED, 0=NOT DESKEWED):** Indicates whether the image has been geometrically corrected to account for non-zero Doppler processing skew inherent in SAR processing. Deskewed imagery has azimuth direction parallel to the aircraft flight track and range perpendicular to this, i.e. parallel to zero Doppler. Skewed imagery has the range dimension parallel to the range beam center footprint on the ground, which is determined by the aircraft yaw and pitch.

Field 68 **SLANT RANGE SAMPLE SPACING (METERS):** The slant range distance in meters between slant range output samples.

Field 69 **NOMINAL SLANT RANGE RESOLUTION (METERS):** The nominal 3dB range resolution given the chirp bandwidth and the weighting function used.

Field 70 **AZIMUTH SAMPLE SPACING (METERS):** The distance on the ground between azimuth samples in the imagery.

Field 71 **NOMINAL AZIMUTH RESOLUTION (METERS):** The nominal 3dB azimuth resolution given the Doppler bandwidth processed, the nominal aircraft velocity and the azimuth weighting.

Field 72 **NUMBER OF INTERPOLATION PNTS USED IN RMC:** In order to correct for range migration, data are interpolated in range to extract a migration corrected azimuth spectral line. The interpolation method used is a $\sin(x)/(x)$ interpolator using the number of points specified. (A value of 0 indicates no RMC was performed, 1 indicates the "cut-and-paste" method.)

Field 73 **AZIMUTH REFERENCE SIZE/LOOK, NEAR RANGE:** The number of points used in the time domain azimuth reference function for each look at near range.

Field 74 **AZIMUTH REFERENCE SIZE/LOOK, FAR RANGE:** The number of points used in the time domain azimuth reference function for each look at far range.

Field 75 **IMAGE CENTER LATITUDE (DEGREES):** The latitude of the image center is approximated by using the known position of the aircraft at the start of the data take, and the radar geometry.

Field 76 **IMAGE CENTER LONGITUDE (DEGREES):** The longitude of the image center is approximated by using the known position of the aircraft at the start of the data take, and the radar geometry.

Field 77 **CALTONE VIDEO FREQUENCY (MHZ):** The frequency of the injected CALTONE at video. This field will be blank if no CALTONE is present.

Field 78 **CALTONE POWER MEASURED, DB, HH:** The relative power of the CALTONE level as measured in the HH data channel.

Field 79 **CALTONE POWER MEASURED, DB, HV:** The relative power of the CALTONE level as measured in the HV data channel.

Field 80 **CALTONE POWER MEASURED, DB, VH:** The relative power of the CALTONE level as measured in the VH data channel.

Field 81 **CALTONE POWER MEASURED, DB, VV:** The relative power of the CALTONE level as measured in the VV data channel.

Field 82 **CALIBRATION FACTOR APPLIED, DB, HH:** The factor that is multiplied by the range compressed HH data in addition to HH antenna correction vector, prior to azimuth compression, to result in output data in units of sigma0.

Field 83 **CALIBRATION FACTOR APPLIED, DB, HV:** The factor that is multiplied by the range compressed HV data in addition to HV antenna correction vector, prior to azimuth compression, to result in output data in units of sigma0.

Field 84 **CALIBRATION FACTOR APPLIED, DB, VH:** The factor that is multiplied by the range compressed VH data in addition to VH antenna correction vector, prior to azimuth compression, to result in output data in units of sigma0.

Field 85 **CALIBRATION FACTOR APPLIED, DB, VV:** The factor that is multiplied by the range compressed VV data in addition to VV antenna correction vector, prior to azimuth compression, to result in output data in units of sigma0.

Field 86 **MEASURED AND CORRECTED HV/VH POWER RATIO:** The HV and VH channel powers are measured after processing.

Field 87 **MEASURED AND CORRECTED HV/VH PHASE (DEG):** The HV and VH phase difference is measured (centroid method) and used in the phase calibration of the compressed Stokes matrix pixels.

Field 88 **CALTONE PHASE MEASURED, DEG, HH:** The phase of the CALTONE as measured in the HH data channel.

Field 89 **CALTONE PHASE MEASURED, DEG, HV:** The phase of the CALTONE as measured in the HV data channel.

Field 90 **CALTONE PHASE MEASURED, DEG, VH:** The phase of the CALTONE as measured in the VH data channel.

Field 91 **CALTONE PHASE MEASURED, DEG, VV:** The phase of the CALTONE as measured in the VV data channel.

Field 92　**GENERAL SCALE FACTOR:** This is the same as the scale factor provided in the calibration header.

Field 93　**GPS ALTITUDE, M:** The aircraft altitude as determined by the GPS receiver in the radar system.

1.2.3 Calibration Header

In the case of calibrated radar data, a calibration header will follow the parameter header. The calibration header consists of four records for compressed polarimetric data, and two records for single channel data. The entries in the first record of this header are shown on the next page. As before, we added the number of the fields on the left and a ruler at the top to make the header easier to read.

```
             0         1         2         3         4
    12345678901234567890123456789012345678901234567890
 1  NAME OF HEADER                      CALIBRATION
 2  GENERAL SCALE FACTOR (dB)                RRR.RR
 3  HH AMPLITUDE CALIBRATION FACTOR (dB)     RRR.RR
 4  HV AMPLITUDE CALIBRATION FACTOR (dB)     RRR.RR
 5  VH AMPLITUDE CALIBRATION FACTOR (dB)     RRR.RR
 6  VV AMPLITUDE CALIBRATION FACTOR (dB)     RRR.RR
 7  HH PHASE CALIBRATION FACTOR (DEGREES)    RRR.RR
 8  HV PHASE CALIBRATION FACTOR (DEGREES)    RRR.RR
 9  VH PHASE CALIBRATION FACTOR (DEGREES)    RRR.RR
10  VV PHASE CALIBRATION FACTOR (DEGREES)    RRR.RR
11  HH NOISE EQUIVALENT SIGMA ZERO (dB)      RRR.RR
12  VH NOISE EQUIVALENT SIGMA ZERO (dB)      RRR.RR
13  VV NOISE EQUIVALENT SIGMA ZERO (dB)      RRR.RR
14  BYTE OFFSET TO HH CORRECTION VECTOR    IIIIIIII
15  BYTE OFFSET TO HV CORRECTION VECTOR    IIIIIIII
16  BYTE OFFSET TO VV CORRECTION VECTOR    IIIIIIII
17  NUMBER OF BYTES IN CORRECTION VECTORS  IIIIIIII
18-20    TBD
```

The first record of the calibration header is followed by a number of records containing the radiometric correction vectors for different polarization combinations. In the case of polarimetric data, there are three such records, while in the case of single polarization data, there is only one such record. The values of the radiometric correction vectors are stored as ASCII values, where each range cell uses up 8 bytes, *i.e.* the numbers are written as F8.2 FORTRAN statements. Each number then represents the radiometric correction applied for a single range cell in dB. This means that the values can simply be typed out, and means that this information is also machine independent. Note that the supplied radiometric correction vector is calculated assuming zero roll angle for the aircraft. The actual data are corrected taking anto account the actual (variable) roll angle of the aircraft.

The first record of the calibration header consists of 20 fields of 50 ASCII characters. These fields have the following meaning:

Field 1　　**NAME OF HEADER:**　This field defines the type of header.　For the calibration header, this is always "CALIBRATION".

Field 2　　**GENERAL SCALE FACTOR (dB):**　The general scale factor is the factor to multiply all data values by to get σ^0.　This is the same quantity we used to supply in the Old Header.

Field 3　　**HH AMPLITUDE CALIBRATION FACTOR (dB):**　This is the number we multiplied the HH channel by in the processor to ensure that the HH data are calibrated.

Field 4　　**HV AMPLITUDE CALIBRATION FACTOR (dB):**　This is the number we multiplied the HV channel by in the processor to ensure that the HV data are calibrated.

Field 5　　**VH AMPLITUDE CALIBRATION FACTOR (dB):**　This is the number we multiplied the VH channel by in the processor to ensure that the VH data are calibrated.

Field 6　　**VV AMPLITUDE CALIBRATION FACTOR (dB):**　This is the number we multiplied the VV channel by in the processor to ensure that the VV data are calibrated.

Field 7　　**HH PHASE CALIBRATION FACTOR (DEGREES):**　This value was used in the phase calibration of the HH data in the processor.

Field 8　　**HV PHASE CALIBRATION FACTOR (DEGREES):**　This value was used in the phase calibration of the HV data in the processor.

Field 9　　**VH PHASE CALIBRATION FACTOR (DEGREES):**　This value was used in the phase calibration of the VH data in the processor.

Field 10　**VV PHASE CALIBRATION FACTOR (DEGREES):**　This value was used in the phase calibration of the VV data in the processor.

Field 11　**HH NOISE EQUIVALENT SIGMA ZERO (dB):**　If no radiometric correction was applied, this would be the constant value of the HH noise equivalent sigma zero.

Field 12　**HV NOISE EQUIVALENT SIGMA ZERO (dB):**　If no radiometric correction was applied, this would be the constant value of the HV noise equivalent sigma zero.

Field 13　**VV NOISE EQUIVALENT SIGMA ZERO (dB):**　If no radiometric correction was applied, this would be the constant value of the VV noise equivalent sigma zero.

Field 14   **BYTE OFFSET TO HH CORRECTION VECTOR:** This determines the position of the HH correction vector in the file. This offset in bytes is from the start of the file. If the HH correction vector is not present, this value is zero.

Field 15   **BYTE OFFSET TO HV CORRECTION VECTOR:** This determines the position of the HV correction vector in the file. This offset in bytes is from the start of the file. If the HV correction vector is not present, this value is zero.

Field 16   **BYTE OFFSET TO VV CORRECTION VECTOR:** This determines the position of the VV correction vector in the file. This offset in bytes is from the start of the file. If the VV correction vector is not present, this value is zero.

Field 17   **NUMBER OF BYTES IN CORRECTION VECTORS:** This is the total number of bytes in each correction vector.

1.2.4 DEM Header

In the case of the DEM file, a special header will follow the parameter header. This header consists of twenty fields as shown below, and contains information specific to the elevations and geolocation of the image. As before, we added the number of the fields on the left and a ruler at the top to make the header easier to read.

```
          0         1         2         3         4
          12345678901234567890123456789012345678901234567890
       1  NAME OF HEADER                           DEM
       2  GEOID MODEL                              WGS84
       3  PLANIMETRIC REFERENCE SYSTEM             UTM
       4  UTM ZONE CODE                            TBD
       5  X-DIRECTION POST SPACING (M)             RR.R
       6  Y-DIRECTION POST SPACING (M)             RR.R
       7  ELEVATION INCREMENT (M)                  R.R
       8  ELEVATION OFFSET (M) =                   RRRR.R
       9  LATITUDE OF CORNER 1 =                   RRR.RR
      10  LONGITUDE OF CORNER 1 =                  RRR.RR
      11  LATITUDE OF CORNER 2 =                   RRR.RR
      12  LONGITUDE OF CORNER 2 =                  RRR.RR
      13  LATITUDE OF CORNER 3 =                   RRR.RR
      14  LONGITUDE OF CORNER 3 =                  RRR.RR
      15  LATITUDE OF CORNER 4 =                   RRR.RR
      16  LONGITUDE OF CORNER 4 =                  RRR.RR
      17  LATITUDE OF PEG POINT =                  RRR.RR
      18  LONGITUDE OF PEG POINT =                 RRR.RR
      19  HEADING AT PEG POINT (DEGREES) =         RRRR.R
      20  TBD
```

Field 1   **NAME OF HEADER:** This field defines the type of header. For the DEM header, this is always "DEM".

Field 2   **GEOID MODEL:** This defines the goid model used when translating heights from height above a plane to height above a geoid surface. The current model used is a spherical approximation to the WGS84 geoid.

Field 3   **PLANIMETRIC REFERENCE SYSTEM:** This defines the planimetric reference system used. *This is not yet implemented.* When implemented, products will be in UTM coordinates.

Field 4   **UTM ZONE CODE:** This field specifies the UTM zone used. *This is not yet implemented.*

Field 5   **X-DIRECTION POST SPACING (M):** This specifies the along-track post spacing in meters. In the current files, this is the spacing betwen successive lines in the image.

Field 6   **Y-DIRECTION POST SPACING (M):** This specifies the cross-track post spacing in meters. IN the current files, this is the spacing between successive pixels in a line.

Field 7   **ELEVATION INCREMENT (M):** This corresponds to the difference in elevation for an increment of one in the INTEGER*2 file.

Field 8   **ELEVATION OFFSET (M):** This is the overall elevation offset for the file.

Field 9   **LATITUDE OF CORNER 1:** The approximate latitude of the first pixel of the first line in the file.

Field 10   **LONGITUDE OF CORNER 1:** The approximate longitude of the first pixel of the first line in the file.

Field 11   **LATITUDE OF CORNER 2:** The approximate latitude of the last pixel of the first line in the file.

Field 12   **LONGITUDE OF CORNER 2:** The approximate longitude of the last pixel of the first line in the file.

Field 13   **LATITUDE OF CORNER 3:** The approximate latitude of the last pixel of the last line in the file.

Field 14   **LONGITUDE OF CORNER 3:** The approximate longitude of the last pixel of the last line in the file.

Field 15   **LATITUDE OF CORNER 4:** The approximate latitude of the first pixel of the last line in the file.

Field 16   **LONGITUDE OF CORNER 4:** The approximate longitude of the first pixel of the last line in the file.

Field 17   **LATITUDE OF PEG POINT:** The approximate latitude of the peg point. The peg point coordinates are used to calculate the spherical approximation to the WGS84 geoid.

Field 18   **LONGITUDE OF PEG POINT** The approximate longitude of the peg point. The peg point coordinates are used to calculate the spherical approximation to the WGS84 geoid.

Field 19   **HEADING AT PEG POINT (DEGREES):** Aircraft heading at the peg point. This is used together with the coordinates of the peg point to calculate the spherical approximation to the WGS84 geoid for this image.

Field 20   **TBD**

In the following sections we shall describe the data formats for the different products produced by the integrated processor in more detail.

1.3 Integrated TOPSAR Data

The integrated TOPSAR data product consist of a number of different data types as shown in the data cube below in Figure 1.2.
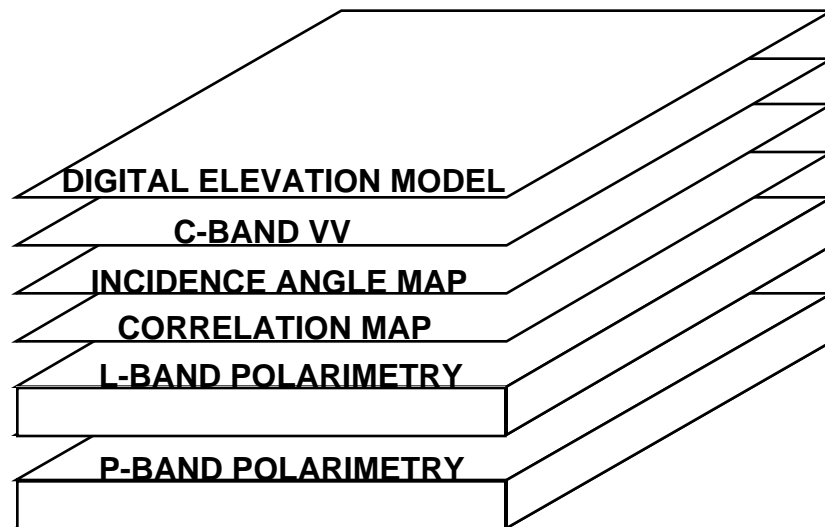
Figure 1.2. *Integrated TOPSAR data cube.*

All data files are in *ground range projection* and in *range line format.* The ground data projection is done using the digital elevation model derived from the C-band interferometry. Range line format means that each record in the data file correspond to constant along-track position (azimuth) and varying cross-track position (range) as described earlier. Data products are distinguished by a CCT type TS followed by a number.

1.3.1 Digital Elevation Model

The first data file contains the digital elevation model derived from the C-band interferometry. The file contains the first two headers described in the previous section, followed by the DEM header, followed by the data. The data are INTEGER*2 in a format compatible with Sun computers, *and represents the elevation of the terrain above a spherical approximation to the WGS-84 ellipsoid.* The radius of this approximating sphere is calculated using a so-called "peg point." This peg point is approximately the center of the image. The radius of the approximating sphere is

$$R_a = \frac{R_e(\lambda_0)R_n(\lambda_0)}{R_e(\lambda_0)\cos^2(\eta) + R_n(\lambda_0)\sin^2(\eta)}$$

with R_e and R_n the east and north radius of curvature at the peg point, respectively. Also, λ_0 is the latitude of the peg point, and η is the heading at the peg point. The east and north radii of curvature are calculated as follows

$$R_e(\lambda_0) = \frac{a}{\sqrt{1 - e^2 \sin^2(\lambda_0)}}$$

and

$$R_n(\lambda_0) = \frac{a(1 - e^2)}{\sqrt{(1 - e^2 \sin^2(\lambda_0))^3}},$$

where a and e^2 are the equatorial radius and the ellipticity of the WGS84 geoid, respectively. These values are:

$$a = 6378.137 \text{ km}$$

and

$$e^2 = 0.00669437999015.$$

When translating elevations above a flat earth to elevations above the approximating sphere, we use the fact that the ground range to each pixel (typicall less than 20 km) is small compared to the radius of the sphere (on the order of 6000 km), which gives

$$h_s = h_f + \frac{R_g^2}{R_a + h_f}$$

with R_g the ground range to the pixel, and the subscripts s and f refer to spherical and flat earths, respectively.

It is important to know the details of the approximating sphere when one wants to mosaic adjacent images that were projected using different peg points.

To translate the integer*2 values supplied in the file to elevations in meters, one has to apply the following calculation

$$h_s = (\text{elevation increment}) * DN + (\text{elevation offset})$$

where DN is the integer*2 (signed) number from the file, elevation increment is the elevation increment found in field 7 of the DEM header, and elevation offset is the elevation offset supplied in field 8 of the DEM header.

1.3.2 C-Band VV Data

The second file contains the calibrated C-band VV polarized data for the scene as acquired with the top antenna used in the TOPSAR mode. The radiometric corrections are performed taking into account the topography when removing the antenna patterns and the scattering areas. The file contains all three header types, and only one radiometric correction vector for VV polarization. The values are stored as the amplitude, i.e. as the square root of the power, and are represented by INTEGER*2 format compatible with a Sun computer.

To translate the integer*2 values supplied in the file to radar cross-sections, one has to apply the following calculation:

$$\sigma^o = \frac{\left(DN^2\right)}{(\text{General scale factor})}$$

where DN is the integer*2 number supplied in the file, and General scale factor is the general scale factor supplied in field 2 of the calibration header.

1.3.3 Incidence Angle Map

The third file is a local incidence angle map, derived using the digital elevation model. The incidence angle is defined as the angle between the normal to a surface element and the radar look direction. The values are stored as one byte, scaled linearly from 0 degrees (byte value = 0) to 180 degrees (byte value = 255). The file does not contain the calibration or DEM header.

1.3.4 Correlation Map

The fourth file contains the normalized correlation coefficient between the two C-band interferometric channels. This quantity has been shown to be related to the height error in the elevation maps. Low correlation means that the expected height error is larger than areas with high correlation. Values are stored as one byte, scaled linearly between 0 (byte value = 0) and 1 (byte value = 255). The file does not contain the calibration or DEM header.

1.3.5 L-Band Polarimetry Data

This file contains the L-band polarimetric data in the AIRSAR compressed Stokes matrix format. Each pixel is represented by 10 bytes in this format. The file contains all headers, including the calibration header with all three radiometric correction vectors.

The Stokes matrix is a 4x4 real matrix (van Zyl and Ulaby, 1990). The most important assumption behind the AIRSAR data compression scheme is that the measured scattering matrix should be symmetric, *i.e.* $S_{vh} = S_{hv}$ This follows from reciprocity (van Zyl and Ulaby, 1990) and the fact that the AIRSAR operates in the backscatter mode. The resulting Stokes matrix will also be symmetrical. The expressions relating the elements of the Stokes matrix, **M** to the elements of the scattering matrix, **S**, in this case are:

$$M_{11} = \frac{1}{4}[S_{hh} \cdot S_{hh}^* + S_{vv} \cdot S_{vv}^* + 2S_{hv} \cdot S_{hv}^*]$$

$$M_{12} = \frac{1}{4}[S_{hh} \cdot S_{hh}^* - S_{vv} \cdot S_{vv}^*]$$

$$M_{13} = \frac{1}{2}\Re[S_{hh} \cdot S_{hv}^*] + \frac{1}{2}\Re[S_{hv} \cdot S_{vv}^*]$$

$$M_{14} = -\frac{1}{2}\Im[S_{hh} \cdot S_{hv}^*] - \frac{1}{2}\Im[S_{hv} \cdot S_{vv}^*]$$

$$M_{22} = \frac{1}{4}[S_{hh} \cdot S_{hh}^* + S_{vv} \cdot S_{vv}^* - 2S_{hv} \cdot S_{hv}^*]$$

$$M_{23} = \frac{1}{2}\Re[S_{hh} \cdot S_{hv}^*] - \frac{1}{2}\Re[S_{hv} \cdot S_{vv}^*]$$

$$M_{24} = -\frac{1}{2}\Im[S_{hh} \cdot S_{hv}^*] + \frac{1}{2}\Im[S_{hv} \cdot S_{vv}^*]$$

$$M_{33} = \frac{1}{2}S_{hv} \cdot S_{hv}^* + \frac{1}{2}\Re[S_{hh} \cdot S_{vv}^*]$$

$$M_{34} = -\frac{1}{2}\Im[S_{hh} \cdot S_{vv}^*]$$

$$M_{44} = \frac{1}{2}S_{hv} \cdot S_{hv}^* - \frac{1}{2}\Re[S_{hh} \cdot S_{vv}^*]$$

where $\Re[]$ and $\Im[]$ represent the real and imaginary parts of the subsequent quantities, respectively. The remaining elements are filled in using the assumption that the

matrix is symmetric. It is easily shown using the expression above that (van Zyl, 1985)

$$M_{11} = M_{22} + M_{33} + M_{44}$$
$$M_{13}M_{23} + M_{14}M_{24} = M_{12}\left(M_{11} - M_{22}\right)$$
$$M_{13}M_{14} + M_{23}M_{24} = M_{34}\left(M_{33} + M_{44}\right)$$
$$M_{13}^2 + M_{14}^2 + M_{23}^2 + M_{24}^2 = M_{11}^2 - M_{22}^2$$
$$M_{13}^2 - M_{14}^2 - M_{23}^2 + M_{24}^2 = M_{33}^2 - M_{44}^2$$

Once one averages a number of Stokes matrices, as is done during the multi-look procedure, only the first of these five relationships still remain. This means that a maximum of 9 independent numbers per Stokes matrix results after averaging. We therefore only need to store 9 numbers for each Stokes matrix.

The compression procedure originally introduced by Dubois and Norikane (1987), is implemented as follows. First, the average of the phase difference between the *vh* and *hv* components of the scattering matrix is measured using a subset of the scene. Then, the scattering matrix is symmetrized by performing the following calculation:

$$S_{hv} = \frac{1}{2}\left[S_{hv} + S_{vh}e^{i\phi_{vh-hv}}\right]$$

where ϕ_{vh-hv} is the average of the phase difference between the *vh* and *hv* components of the scattering matrix. This symmetrized matrix is then used to calculate the symmetrical Stokes scattering operator. The value of ϕ_{vh-hv} is saved in the parameter header of the data file, as described earlier.

Next, each data set is scaled by a single value for all pixels such that the dynamic range of the total power elements in the Stokes matrices (the M_{11} element) falls within values between 2^{-128} and 2^{127}. Since radar images typically exhibit a dynamic range less than 30 dB, this condition is easily met. The total power for each matrix is then coded into two bytes, one for the exponent in the above range and one for the mantissa. The remaining eight elements are then normalized to the M_{11} element in the Stokes matrix.

Four of these elements (those related to the cross products of co- and cross-polarized channels) are observationally found to be much smaller than M_{11}; many theories predict these elements to be small or zero for most natural surfaces. Therefore, before encoding, the square root of each of the four normalized elements is calculated.   Each of the eight values is next truncated to eight bits (one byte) and the resulting eight bytes are saved. These eight bytes plus the two for the total power are then stored, requiring only 10 bytes per pixel.

The equations for the compression and decompression operations are given here. For data encoding from the Stokes matrix to the compressed 10 byte format, the following apply:

$$\text{byte(1)} = \text{Int}\left(\frac{\log_2 M_{11}}{\log_2 2}\right)$$

where $\text{Int}(\ )$ is the integer part of the subsequent quantity.

$$\text{byte(2)} = \text{Int}\left(254 \cdot \left(\frac{M_{11}}{2^{\text{byte(1)}}} - 1.5\right)\right)$$

We then compute a normalization factor x approximately equal to M_{11}. Choosing this factor for normalization results in slightly smaller errors than using M_{11} directly:

$$x = \left(\frac{\text{byte(2)}}{254} + 1.5\right) \cdot 2^{\text{byte(1)}} \cdot gen\_fac$$

The general scale factor, gen_fac is the average of all the M_{11} values in the image, and is stored in field 2 of the calibration header. The remaining eight bytes are coded as follows, with $\text{sign}(\ ) = \pm 1$, reflecting the sign of the quantity in brackets:

$$\text{byte(3)} = 127 \cdot M_{12} / x$$
$$\text{byte(4)} = 127 \cdot \text{sign}(M_{13} / x) \cdot \sqrt{M_{13} / x}$$
$$\text{byte(5)} = 127 \cdot \text{sign}(M_{14} / x) \cdot \sqrt{M_{14} / x}$$
$$\text{byte(6)} = 127 \cdot \text{sign}(M_{23} / x) \cdot \sqrt{M_{23} / x}$$
$$\text{byte(7)} = 127 \cdot \text{sign}(M_{24} / x) \cdot \sqrt{M_{24} / x}$$
$$\text{byte(8)} = 127 \cdot M_{33} / x$$
$$\text{byte(9)} = 127 \cdot M_{34} / x$$
$$\text{byte(10)} = 127 \cdot M_{44} / x$$

To reconstruct the Stokes matrix from the reduced data, the following inverse operations are required:

$$M_{11} = \left(\frac{\text{byte(2)}}{254} + 1.5\right) \cdot 2^{\text{byte(1)}} \cdot gen\_fac$$
$$M_{12} = \text{byte(3)} \cdot \frac{M_{11}}{127}$$
$$M_{13} = \text{sign}(\text{byte(4)}) \cdot \left(\frac{\text{byte(4)}}{127}\right) \cdot M_{11}$$
$$M_{14} = \text{sign}(\text{byte(5)}) \cdot \left(\frac{\text{byte(5)}}{127}\right) \cdot M_{11}$$
$$M_{23} = \text{sign}(\text{byte(6)}) \cdot \left(\frac{\text{byte(6)}}{127}\right) \cdot M_{11}$$
$$M_{24} = \text{sign}(\text{byte(7)}) \cdot \left(\frac{\text{byte(7)}}{127}\right) \cdot M_{11}$$

$$M_{33} = \text{byte}(8) \cdot \frac{M_{11}}{127}$$

$$M_{34} = \text{byte}(9) \cdot \frac{M_{11}}{127}$$

$$M_{44} = \text{byte}(10) \cdot \frac{M_{11}}{127}$$

$$M_{22} = M_{11} - M_{33} - M_{44}$$

1.3.6 P-Band Polarimetry Data

This file contains the P-band polarimetric data in the AIRSAR compressed Stokes matrix format. Each pixel is represented by 10 bytes in this format. The file contains all headers, including the calibration header with all three radiometric correction vectors. The compression scheme is the same as that described in the previous section.

Note: Due to a frequency allocation restriction, P-band data were not collected in the 40 MHz mode during the FY 1994 flight season. This file may therefore not be present for all data sets.

References

P. C. Dubois and L. Norikane, "Data volume reduction for imaging radar polarimetry," *Proc. of IGARSS '89 Symposium,* 1987.

J. J. van Zyl and F. T. Ulaby, "Scattering matrix representations for simple targets," *Radar polarimetry for Geoscience Applications,* Artech House, Norwood, MA, pp. 17-52, 1990.

J. J. van Zyl, On the Importance of Polarization in Radar Scattering Problems, Ph.D. Thesis, Antenna Laboratory Report No. 120, 152 pp., California Institute of Technology, Pasadena, CA, 1985.